International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 7 Issue 3, May-June 2023 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Development of Smart Trailing Trolley

Yanshio Emmanuel Terngu[1], Ali Ummi Ene[2], Eje Jonathan Ogbor[3]

[1]Lecturer, [2,3]Student,

[1,2,3]Department of Mechanical Engineering, Joseph Sarwuan Tarka University, Makurdi, Benue, Nigeria

ABSTRACT

The shopping trolley was modernized into a smart shopping trolley, from a pushing to a trailing device as an essential gadget useable by shoppers in shopping malls and other customer related procurement centers. The software developed for the modified trolley was written using the C and C++ programming languages on the Arduino open-source integrated development environment. The design was divided into two parts, the electrical and the mechanical sections, respectively. The electrical section comprised of the DC motor with wheel encoder, electronic compass, Arduino uno and Arduino mega, voltage regulators, resistors, cables, capacitors, transistors, electronic buttons, RFID, LED, transmitter and receiver, batteries, and buzzer. The mechanical sections, on the other hand, were made up of sheet metal, aluminum sheet, metallic plates, plastic casing, MPU 6500 gyroscope and accelerometer, and motor drivers. A remote control (plotter pad) was designed alongside the trolley, with a transmitter and receiver incorporated into both the remote control and the trolley. The device, once activated on the plotter pad, transmits a signal to the trolley, and it subsequently trails the shopper with the remote control acting as a control device. Any obstacle in the path of the trolley will be detected using the HCSR04 ultrasonic sensor. The design ensures that shoppers would spend less time shopping as pushing trolleys would be no more involved, and the anxieties borne out of anticipated stress would be eliminated. The result showed that the ultrasonic sensor enabled the trolley to detect obstacles, the trolley was able to successfully trail the shopper, and the time shoppers spent while shopping was greatly minimized. The study recommends that the designed smart trailing trolley be adopted by all shopping centers and malls to attract customers and boost shopping businesses.

How to cite this paper: Yanshio Emmanuel Terngu | Ali Ummi Ene | Eje Jonathan Ogbor "Development of Smart Trailing Trolley" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-3, June 2023, pp.1294-1298, URL: www.ijtsrd.com/papers/ijtsrd58583.pdf

IJTSRD58583

KEYWORDS: *Smart, Arduino, Trolley, Trailing, Modernized, Cart*

1. INTRODUCTION

Shopping malls are one of the most popular places for leisure activities, shopping, and entertainment, which attract many people every day. With the increasing popularity of online shopping, shopping centres are faced with the challenge of retaining customers. As a result, shopping malls have been looking for innovative ways to provide a more personalized shopping experience to attract and retain customers. One such solution is smart trailing trolleys.

A shopping trolley (Cart) is a large basket on wheels that is used to carry goods in malls or shopping centers. The birth of shopping carts in the early 20th century helped usher in an era of mass Consumption and enabled grocery stores and brands to expand their products without customers worrying about how they would get stuff to their cars [2]. Since the efforts of Goldman and Watson, several other efforts have been made in modernizing the shopping trolley that is used to carry purchased items from the stores to vehicular parks to further convey them home. They often come in various designs and capacities. The shopping trolley is one of the most successful marketing inventions of the 20th century. It came into existence in 1937 by the American supermarket owner Goldman Sylvan as a way of encouraging his customers to buy more items from his Humpty Dumpty chain of stores [2&6].

Shopping ordinarily is one of the most interesting things to do, especially when you can conveniently push the items you pick in a trolley or cart within the shopping mall. The shopping trolley is pushed within the shopping area by the shopper while he/she picks

the items needed. But it is less interesting and very stressful for some categories of people, thereby making it almost impossible for such people to enjoy shopping as most people do. These shoppers complain about obvious difficulties such as squeaky wheels while being pushed, irritating noises, and non–alignment of the carts, making them bump into aisles requiring the shopper to have to push them all the time. The Nationwide Children Hospitals of America has reported cases of injuries, concussions, and even death from shopping trolley-related accidents [5] Since these trolleys are manually handled, bumping into shelves and persons in the shopping mall has become a regular problem many shoppers have had to face while using the trolley. The designers of the present shopping trolleys in use have failed to take a comprehensive assessment of the individual needs required of a built person-centered care plan [1].

The supermarket is a shopping centre that sells many kinds of products. In the current pandemic, supermarkets also swiftly follow the government's protocol by checking the temperature of every person who comes in. However, the protocol required in some facilities that had not become the focus in the supermarkets is the trolley. As a result, a smart trolley was designed. The smart trolley is an innovation that prevents the transmission of COVID-19. This product allows people to use shopping trolleys without touching the trolley's handle. Also, some facilities like sterilizers will clean the trolley when the shoppers use it to keep the trolley clean [3].

The Recent enormous number of advancements in the field of Internet of Things (IoT) technology has given way to new applications and fields. The interfacing with sensors and actuators plays the combined role of environmental sensing, specific computing, and wirelessly communicating devices. Due to the factors accompanied by the effectiveness for miniaturization of hardware, fast sensing types of equipment, energy saving and scavenging, and the fact that many applications cannot be wired, IoT technology makes it suitable for various application domains such as medicine and health care, environment, and industrial monitoring. Nowadays, the proliferation of supermarkets and shopping malls, added to the rapid development of IoT technology, has produced various intelligent systems for helping customers in shopping efficiency. Toward the concept of the smart mall, the IoT technology embeds networks of sensors and actuators in buildings that can effectively function in data collection and management so that it is anticipated to significantly improve the quality of shopping services [4].

Based on the above challenges and factors a new concept known as "a smart trailing trolley" is developed using the factors to overcome some of the challenges. This trolley has batteries that contain stored energy with motors on its wheels and a customer location identifier which sends the coordinates of the point where the customer is to it when the infrared plotter on the hand of the customer falls in the line of sight with the infrared customer location identifier. It has many advantages, such as saving shopping time, making shopping less stressful for the aged, pregnant women, disabled, etc., and making shopping more enjoyable. The smart shopping trolley is one of the improved models of shopping trolleys.

2. MATERIALS AND METHODS

Materials used include Sheet metal, Aluminum sheet, Metal plates, DC Motor with Wheel Encoder, Electronic Compass, MPU 6500 Gyroscope and accelerometer, Arduino Uno, Arduino Mega, Motor drivers, Voltage Regulator LM2596, Resistors, Capacitors, Printed Circuit board, nRF24L01, Terminals and Connectors, Ultrasonic sensors, Transistors, Buzzer, Electronic buttons, Batteries, Linear voltage regulator, Cables, Radio Frequency Identification (RFID), Casing, Light Emitting Diode (LED), and Transmitters.

2.1. METHODS

2.1.1. Design and Development

The design parameters is such that it supports the load it is intended for and is duly analyzed to ensure they also have dynamic stability for the trolley. This requires that accurate dimensions, the surface texture of materials, and fasteners are accurately selected, more so it is important that when in motion or under stress which is out of tolerable range, the trolley's center of gravity should always fall within its support area, which is the area formed by the shape underneath it. To ensure this, the trolley's height is designed to be very close to the ground.

2.1.2. Design of mechanical support (Trolley)

A. Aluminum Chassis: This is a rectangular mold that has its breadth area both rear and front removed. Its surface areas are:

Top surface area = Length * breadth [1]

190 mm * 83 mm= 15,770 mm² [2]

Side surface area= 2* Length * breadth

2* 190*23= 8,740 mm²

This frame was designed to give a height of 23 mm from the link mechanism and supports the carriage of load without failure.

B. Electric Motor Support Frame

This is made up of a metallic material. It has a diameter of 10 mm to which the shaft of the motor extends out to carry the wheels. The motors are fastened to it through two 0.5-diameter grooves. The dimensions are:

Length = 100 mm

Heights= 30 mm

Breadth= 25 mm

C. Static Support Frame (Front frame):

This is a metallic bar of dimensions:

Length = 165 mm

Breadth = 30 mm

Thickness= 7 mm

Two caster wheels are mounted on both ends with base area:

Length: 41 mm

Breadth: 41 mm

Base area = Length * breadth [3]

41*41= 1,681 mm².

D. Link Mechanism:

This is a sheet metal that connects the front and rear wheels with the dimensions:

Length = 163 mm

Breadth = 83 mm

Thickness= 1 mm

E. Load Frame:

This is an aluminum sheet with dimensions.

Breadth= 140 mm

Length= 200 mm

Thickness= 2 mm

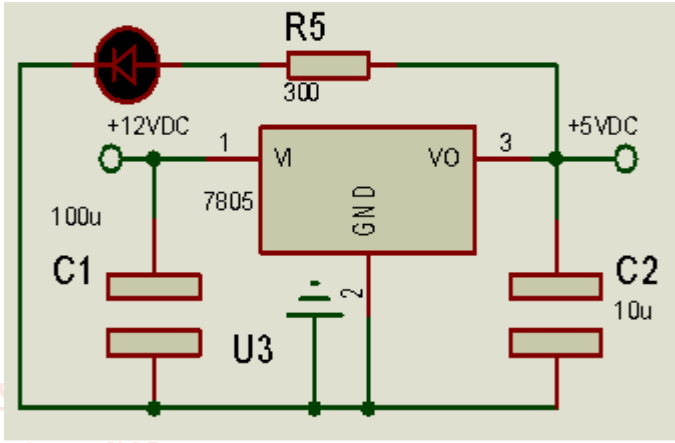
This is incorporated to extend load and to carry nets which helps to support very tall loads. This helps to basically stop loads from falling when the trolley is in motion.

2.1.3. Design of electrical circuit

In the design of the electrical circuit, it is imperative that the electrical components used can withstand the stress that will be imposed on them during motion or use. This ensures that the parts are carefully modeled and mathematically expressed such that the solutions of the equations predict values that are obtainable in the market and will eventually size their requirements. For instance, when the trolley is loaded, the tractional force required to overcome friction is proportional to the magnetic flux generated in the electric motor and is also proportional to the current deliverable to the coils of the motor. If the electric motor drivers are not sized properly, they might burn out, due to excessive heat which is due to high rate of flow of current in the integrated circuit.

2.1.4. Design of power supply

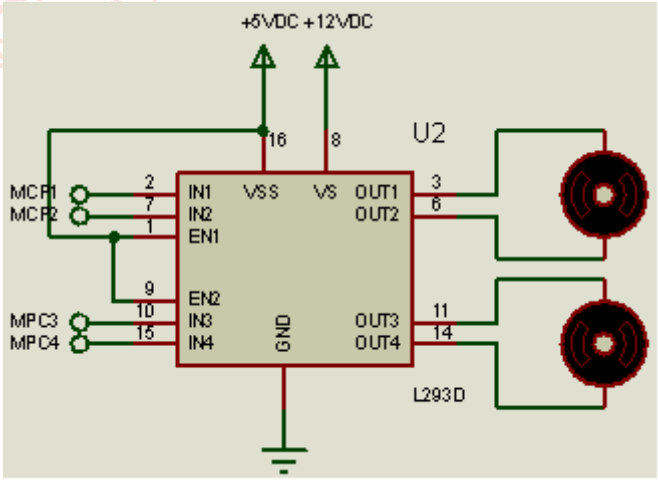
The source of power supply to the circuit is a 12 VDC, 11000 mAH battery; this can withstand 11 amperes for 1 hour. A battery is chosen because it is a mobile device and needs no external cable for a power supply. Most integrated circuits used on the circuit require a 5 VDC supply. This is made available using linear voltage regulators, as shown in the figures below.



VDC Regulator Circuit

2.1.5. Design of the motor drivers

Motor drivers act as an interface between the motors and the control circuits. The motor requires a high amount of current whereas the controller circuit works on low current signals. So, the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor. The motor driver used is L298N. It is an integrated circuit able to drive two wheels delivering up to 0.8A. The DC motors used for the trolley is a 12V, 95RPM. The circuit is shown below.



Motor driver circuit

2.1.6. Design of the robot presence indicator

We require that the trolley is easily detected anywhere in the operating environment; this we achieve with light emitting diode, which is a combination of both red and blue light frequencies. These lights are constantly ON. The microcontroller supplies a 5 V signal to the base of the transistor,

which switches the transistor ON according to the following formula.

$V_s - V_R - V_{LED} - V_{CE} = 0$ [4] Kirchhoff's Voltage Law

$12 - V_R - 2.7 - 0.2 = 0$

$V_R = 12 - 2.7 - 0.2 = 9.1$ V

V_R = IR (Ohms law) [5]

IR = 9.1

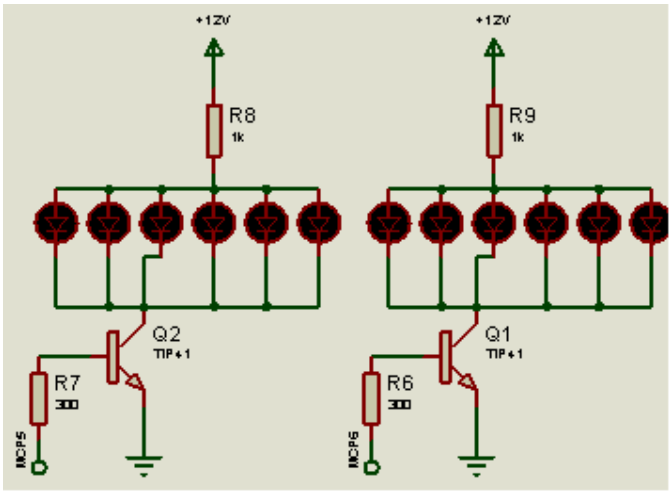
Choosing a minimum current of 10 mA, which is the required brightness level.

10 mA*R = 9.1

R = 9.1/10 mA = 0.91* 1000 = 910Ω ~ 1K Ω.

The sizing of the base transistor is calculated using the current flowing through its collector Ic and its trans conductance β.

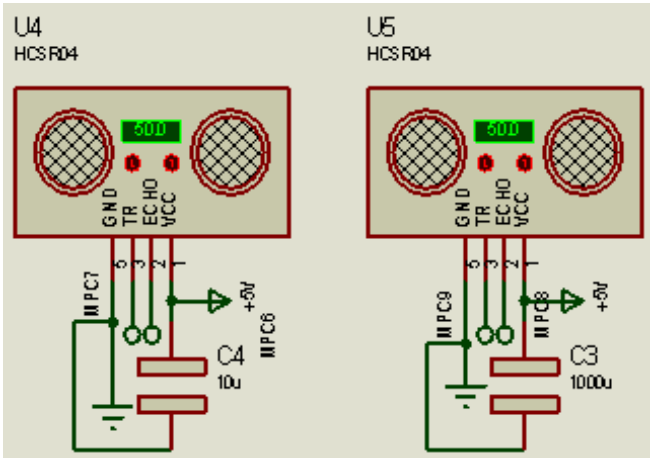
Ib is >>Ic/β



LED circuit

2.1.7. Design of the obstacle avoidance system

Obstacles in the path of the trolley are detected using the HCSR04 ultrasonic sensor which sends high-frequency sound waves through its trigger pin and waits for its echo to calculate time which is consequently used to determine the distance of objects from it. It uses the echo distance formula $V = \frac{2X}{T}$



Obstacle detector circuit

2.2. Software Development

The software developed for the trolley was written using the C and C++ programming languages on the Arduino open-source integrated development environment. The data obtained from the HMC588L electronics compass is used to determine the heading of the user or the customer in the custody of the plotter pad, this gives us the direction of the person, then using interpolation the trolley is commanded to move in the direction of the unit vector as computed by the formulae provided in the microcontroller.

3. Result and discussion

The modification of the smart trailing trolley is divided into two parts, the electrical and the mechanical sections respectively. The electrical section comprises the DC motor with wheel encoder, electronic compass, Arduino uno and Arduino mega, voltage regulators, resistors, cables, capacitors, transistors, electronic buttons, RFID, LED, transmitter and receiver, batteries, and buzzer.

The mechanical sections comprise sheet metal, aluminum sheets, metallic plates, plastic casing, MPU 6500 gyroscope and accelerometer, and motor drivers. A remote control (plotter pad) was designed alongside the trolley with a transmitter and receiver incorporated into both the remote control and the trolley. The software developed for the trolley is written using the C and C++ programming languages and the Arduino open-source integrated development environment.

The design used the data obtained from the HMC588L electronics compass to determine the heading of the user or the customer in the custody of the plotter pad, this gives us the direction of the person. Once the remote is activated or turned ON the transmitter in the plotter pad transmits signals to the trolley and the trolley receives the signal and begins to trail the shopper holding the remote while the shopper as well gives the trolley the direction in which it will go. The obstacles in the path of the trolley are detected using the HCSR04 ultrasonic sensor which sends high-frequency sound waves through its trigger and waits for its echo to calculate time which is consequently used to determine the distance of objects from it, once an obstacle is detected the buzzer on the remote gives a beep sound to alert the shopper that an obstacle has been detected in its path (the obstacles could be shelves, humans, and so on) the shopper therefore is to change the direction of the trolley to enable it maneuver the obstacle. The source of power supply to the circuit is a 12 V DC, 11000 mAH battery; this can withstand 11 amperes for 1 hour.

After the test running, the trolley the following observation was recorded as shown in the table below.

TABLE 1 Performance parameter between manually pushed trolley and the smart trailing trolley

S/NO	manually pushed trolley	smart trailing trolley
1	Operated manually	Operated using a plotter pad
2	Very stressful	Less Stressful
3	Time Consuming	Not Time consuming
4	Work done is 40%	Work done is 80%
5	Source of movement is human	Source of movement is an electric motor.
6	Bumps into shelves and humans	Does not bump into shelves and humans.

The proposed model was made possible by using a 12 V DC battery to power the trolley and a DC motor with wheel encoders made it possible to move the trolley about successfully while the ultrasonic sensor helps to detect obstacles and the transmitter and receiver in the remote and trolley transmits and receives the signal from each other to give direction as to where the person in the position of the plotter is positioned. The stress and fatigue faced by shoppers while pushing the shopping trolley are greatly reduced after adopting ergonomic techniques during design. Hence analyzing the function and cost with the presently available market, the smart trailing trolley is more efficient with comparatively lesser cost.

Conclusion

After successfully completing the design modification of the smart trailing trolley, the objectives were successfully met, where; the ultrasonic sensor enabled the trolley to detect obstacles, the trolley was able to successfully trail the shopper, the time shoppers spend while shopping was greatly minimized (since they would no longer spend time pushing around trolleys), persons with special needs can now shop with ease. With this new idea, it is expected that shoppers would no longer entertain the fear of being stressed while shopping.

REFERENCES

[1] Cotterill, Diane, Wolverson, Caroline and Boothe, Myesha (2015) Shopping Experiences of People with Learning Disabilities. *Journal of Learning Disabilities Practice* 18(8): 16-21, 2015, Volume 18, Number 10.

[2] Goldman, S. (1937). Fascinating facts about Sylvan Goldman inventor of the shopping cart in 1937.

[3] Halim, G., Rafael, G., Gozali, L. and Salomon, L.L. (2020). Smart Trolley as Sophisticated Supermarket Facility in Covid-19 Pandemic Era. Tarumanagara University, Indonesia.

[4] Hsin-Han Chiang, Wan-Ting You, Shu-Hsuan Lin, Wei-Chih Shih, Yu-Te Liao, Jin-Shyan Lee, and Yen-Lin Chen (2016). development of Smart Shopping Carts with Customer-Oriented Service. International Conference on System Science and Engineering (ICSSE) National Chi Nan University, Taiwan.

[5] PubMed Abstract (2014) Shopping Cart Safety. Nationwide Children Hospital, 700 Children Drive, Columbus, Oh 43205.

[6] Watson, O. (2003). Orla Watson Invented the Grocery Cart with a Basket. *American Profile*.